METHOD OF TEST FOR
MOISTURE-DENSITY RELATIONSHIP OF SOILS USING
2.5 kg RAMMER AND 305 mm DROP

1. SCOPE

1.1 This method covers the determination of the relationship between the moisture content and density of soils using a mold of given size with a 2.5 kg rammer dropped from a height of 304.8 mm. Three alternate procedures are provided as follows:

Procedure 1 - 101.6 mm mold with material passing a 4.75 mm sieve

Procedure 2 - 101.6 mm mold with material passing a 26.5 mm sieve

Procedure 3 - 152.4 mm mold with material passing a 26.5 mm sieve.

1.2 The method to be used should be indicated in the specifications for the material being tested. If no method is specified, the provisions of Procedure 1 shall govern.

2. RELEVANT DOCUMENTS

2.1 ASTM D 698

2.2 AASHTO T 99

3. APPARATUS

3.1 MOLDS: The molds shall be cylindrical in shape, made of metal, with a detachable collar assembly. The mold and collar assembly shall be so constructed that it can be fastened firmly to a detachable base. The dimensions are as follows:

3.1.1 Mold: 101.6 mm internal diameter and meeting the specifications described in ASTM D698.

3.1.2 Mold: 152.4 mm internal diameter and meeting the specifications described in ASTM D698.

3.2 RAMMER

3.2.1 Manually Operated Rammer: Meeting the specifications described in ASTM D698.

3.2.2 Mechanical Rammer: A metal rammer that is mechanically operated by a device equipped to control the height of drop as described in 3.2.1, (Reference to manual rammer, ASTM D698) and to uniformly distribute such drops on the surface of the soil. The operating mass shall be determined from calibration according to MTO Method LS-708, Calibration of Mechanical Laboratory Soil Compactors. There shall be 2.54 ± 0.76 mm clearance between the rammer and the smallest internal diameter of the mold.

3.3 SAMPLE EXTRUDER (Optional): A jack, frame or other hydraulically or mechanically operated device adapted for the purpose of extruding compacted specimens from the mold.

3.4 BALANCES: A balance or scale of at least 15 kg capacity sensitive to 5 g and a balance of at least 1000 g capacity sensitive to 0.1 g.

3.5 DRYING OVEN: A thermostatically controlled oven capable of maintaining a temperature of 110 ± 5°C.

3.6 STRAIGHTEDGE: A steel straightedge 300 mm in length and with one edge beveled.

3.7 MIXING TOOLS: Miscellaneous tools such as a rotatable table on which to place the mixing bowl, spoon, trowel, spatula, etc. together with a means of adding controlled amounts of water to the sample while mixing. A mechanical mixing device may be used for some soils such as sand which will not clog the blades.

4. PREPARATION OF SPECIMEN

4.1 Take a sample weighing approximately 3.5 kg, 4.5 kg or 9 kg for Procedure 1, 2 and 3 respectively, obtained in accordance with the Method of Dry Preparation of Soil Samples (MTO Method LS-700) or the Method for Preparation of Coarse Aggregate (MTO Method LS-600).

5. TEST PROCEDURE

5.1 PROCEDURE 1

5.1.1 Thoroughly mix the representative sample (approximately 3.5 kg) with sufficient water to bring it to approximately four to six percentage points below optimum moisture content.

5.1.2 Form the specimen by compacting the material in the 101.6 mm mold (with collar and base plate attached) in three equal layers to give a final compacted depth not exceeding 127 mm. Each layer shall be compacted by 25 blows of the rammer, uniformly distributed over the surface of the soil. During compaction, the mold shall rest on a rigid base such as provided by a concrete cube weighing not less than 90 kg. When compaction is completed, carefully remove the collar and trim the surface of the soil even with the top of the mold using the straightedge. Remove the base plate and weigh the soil-filled mold. Record the amount of water added and the mass of the soil-filled mold.

5.1.3 Remove the material from the mold and cut vertically through the centre, taking a representative portion to determine and record the moisture content according to the Method of Determination of Moisture Content of Soils (MTO Method of LS-701).

5.1.4 Thoroughly break up the remainder of the material until it will pass a 4.75 mm sieve as judged by eye. Add a sufficient amount of water to increase the moisture content of the sample by one or two percentage points, and repeat the procedure in 5.1.2 for each increment of water added. Continue this procedure until there is either a decrease or no change in the wet density, pm, in g/cm^3 of the compacted soil.

Note 1: This procedure is performed on samples containing less than 15 percent retained on a 4.75 mm sieve material, which is discarded. The maximum wet and dry densities and optimum moisture content must be corrected to account for the effect of the stone content. The correction for amounts less than 5 percent can be ignored as the effect will be negligible.

5.2 PROCEDURE 2

Note 2: This procedure is identical to Procedure 1 with the exception that a 4.5 kg sample of pass 26.5 mm sieve material is used. Any oversize shall be replaced by an equal amount of pass 26.5 mm retained 4.75 mm material which shall have an equivalent grading to that portion of the original sample.

Note 3: This procedure is normally used only when there is insufficient material for preparation of a 9 kg compaction sample.

5.3 PROCEDURE 3

Note 4: This procedure is similar to Procedure 1 with the exception that a 9 kg sample of pass 26.5 mm sieve material is used. The specimens are compacted in three equal layers to give a total depth not to exceed 127 mm in the 152.3 mm mold, each layer being compacted by 56 uniformly distributed blows from the rammer.

Note 5: Any oversize material shall be replaced by an equal amount of pass 26.5 mm retained 4.75 mm material which shall have an equivalent grading to the original sample.

Note 6: In the case of granular 'A' materials, the oversize (pass 37.5 mm, retained 26.5 mm) should be reviewed and the final results corrected for the percent oversize using the graphical construction (Note 7).

5.4 In all these procedures, it is desirable to prepare at least five trials to produce an acceptable compaction curve. The idealized curve would consist of two points increasing in density, then one point at or near the optimum moisture content and maximum density, and two points of decreasing density, all with increasing moisture content.

6. CALCULATION (FIGURE 1)

6.1 Calculate the wet density, in g/cm^3, for each trial by dividing the mass of wet soil by the mold volume in cm^3.

6.2 Calculate the moisture content for each trial according to MTO Method LS-701.

6.3 Calculate the dry density, in g/cm^3 as follows:

$$pd = \frac{pm}{w + 100} \times 100$$

where: w = percentage moisture in the specimen
pd = dry density, g/cm^3

pm = wet density, g/cm^3

6.4 Plot the wet and dry densities in g/cm^3 as ordinates and the corresponding moisture contents as abscissas. Draw two smooth curves, one joining the plotted points for wet densities, and one for dry densities. The moisture content corresponding to the peak of the dry density curve shall be termed the OPTIMUM MOISTURE CONTENT of the soil.

6.5 Corrections to calculated values

6.5.1 The calculations already made for maximum densities and optimum moisture content are on the portion of the soil passing a 4.75 mm sieve and must be corrected in Procedure 1 to compensate for oversize material, which would be included in the material undergoing compaction in the field.

6.5.2 The dry density may be corrected by applying the following formula:

$$W_t = \frac{W_o W_c}{OW_c + CW_o}$$

where: W_t = calculated maximum dry density, g/cm^3

W_o = bulk density of the oversize

W_c = measured maximum dry density of the portion of soil passing a 4.75 mm sieve

O = fraction by mass of oversize particles in the soil expressed as a decimal

C = fraction by mass of the portion of the soil passing a 4.75 mm sieve expressed as a decimal

Note 7: It is more convenient to utilize a graphical construction for the above calculation using a constant figure for the bulk relative density (Figure 2).

6.5.3 The optimum moisture content of the total soil is calculated as follows:

$$M_t = OA_o + CM_c$$

where: M_t = calculated optimum moisture content of the total soil expressed to 0.1 %

O = fraction by mass of the oversize particles expressed as a decimal

A_o = percentage of water absorbed by the oversize

C = fraction by mass of the portion of the soil passing a 4.75 mm sieve, expressed as a decimal

M_c = measured optimum moisture content of the portion of the soil passing a 4.75 mm sieve

Note 8: A figure of 3 % is normally used for A_o but if greater accuracy is required an absorption test shall be performed.

7. REPORTING OF RESULTS

7.1 The report shall indicate the method used and also include the following:

7.1.1 Maximum wet density,

7.1.2 Maximum dry density,

7.1.3 Optimum moisture content

Note 9: Both uncorrected and corrected values for items 7.1 1 and 7.1.2 shall be given and reported to the nearest 0.001 and 7.1.3 to the nearest 0.1 % .

8. GENERAL NOTES AND PRECAUTIONS

8.1 The rammer should always be held in a vertical position during compaction.

8.2 Rebound of the rammer from the top of the sleeve must be avoided, otherwise the compactive effort will change.

8.3 Samples of heavy clays (CI - CH) should be cured at the initial water content for a minimum of 12 h in a plastic bag to ensure even moisture distribution.

8.4 To avoid injury keep fingers away from the ram of the hydraulic extruder or the rammer of the mechanical compactor.

8.5 Obtaining an even surface on a compacted granular material with the straightedge is very difficult. An attempt should be made to balance voids in the surface with an approximately equal number of pieces of aggregate projecting from the surface of the sample, using a round steel rod as a gauge.

8.6 Observe and note if the material under test is being degraded by repeated test runs. If major aggregate breakdown occurs it may be necessary to use fresh material for each run.

8.7 Observe and note the presence and degree of free water.

8.8 Ensure that the rammer is maintained in a clean condition and that no build-up of soil occurs on the rammer which would affect the compactive effort.

8.9 For granular 'A' samples containing material passing 37.5 mm - retained 26.5 mm (Procedures 2 and 3), remove the retained 26.5 mm material, calculate the percentage and use the correction chart (Figure 2) to correct the maximum wet density obtained in the test.

Ontario

LABORATORY TEST FOR SOIL COMPACTION PROCTOR METHOD			LAB No.
DATE	OPERATOR	SAMPLE MASS	
FIELD No.	CONTRACT No.	HIGHWAY No.	
DESCRIPTION			

TEST No.							
WATER ADDED (mL)							
MOLD + WET SOIL							
TARE							
WET SOIL MASS							
WET DENSITY (g/cm^3)							
MOISTURE CONTENT DETERMINATIONS							
TIN No.							
TIN + WET SOIL							
TIN + DRY SOIL							
MOISTURE LOSS							
TARE							
DRY SOIL MASS							
% MOIST							
DRY DENSITY (g/cm^3)							

MOLD No.	VOLUME OF MOLD
MAX. WET DENSITY	g/cm^3
MAX. DRY DENSITY	g/cm^3
OPTIMUM MOISTURE	%
FIELD MOISTURE	
FIELD DENSITY	g/cm^3
COMPACTION	
REPORT BY	

WET DENSITY (g/cm^3)

$$= \frac{WET\ \ SOIL\ \ MASS}{VOL.MOLD}$$

MOISTURE CONTENT

$$= \frac{MOISTURE\ \ LOSS}{DRY\ \ SOIL\ \ MASS} \times 100\%$$

DRY DENSITY (g/cm^3)

$$= \left(\frac{WET\ \ DENSITY}{100 + \%MOISTURE}\right) \times 100\%$$

REMARKS

Figure 1 Compaction Data Sheet

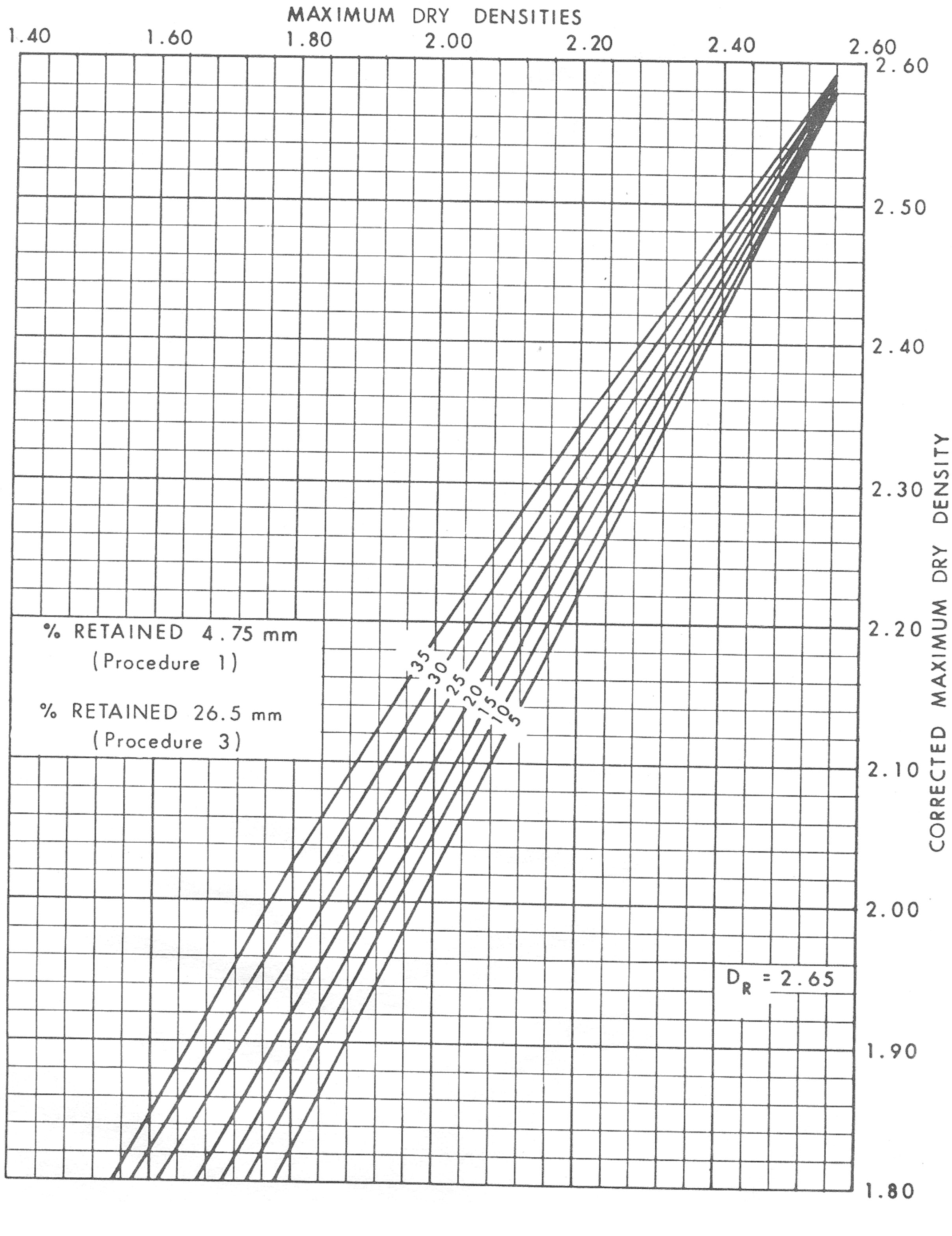

Figure 2 Plus 4.75 mm Correction Table for Dry Densities